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(54) Granular composite containing metal fibers and plastic articles made therefrom.

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Description

The invention relates to a granular plastic composite containing metal fibers and to plastic articles made therefrom.

In the manufacture and shaping of plastic articles plastic granules containing additives are often used whereby these master batch granules are then plastified and mixed intensively with an amount of resin thus forming a viscous mass. This viscous mass can then be shaped into articles by extrusion and/or molding.

Applicant's U.K. Patent 2.150.936 describes the production of a granular composite containing electrically conductive fibers e.g. stainless steel fibers. Such a composite can be used for the shaping of thermoplastic articles with antistatic properties or shielding properties against electromagnetic radiation. According to this patent, fibers are introduced into and uniformly distributed through a plastic by using an intermediate granular composite. In order to attain a reasonable shielding efficiency with a low fiber content (vol. %) in the plastic articles, it is important that during the dispersion a relatively high fiber length L and in particular a high L/D-ratio (≥ 100), where D stands for the equivalent diameter of the conductive fibers, are maintained.

In practice, this means that excessive fiber breakage during the processing into the plastic must be avoided in order to maintain a high L or L/D-value. In addition to these conductive fibers, non-conductive fibers, such as glass fibers, can also be introduced in the form of a granular composite to reinforce the plastic.

Although the dispersion attained according to this patent is good the injection molding process conditions must be controlled very accurately. In particular, the shear forces in the warm, plastified mass to be injection molded must be controlled to achieve a sufficiently uniform dispersion without excessive fiber breakage. This causes the rate of production according to this patent to be relatively low.

Applicant's Belgian patent application No. 8700067 (EP-A-0 278 546) proposes the introduction of a crimping wave into the Fibers by means of gear crimping. The voluminous fiber bundle thus obtained is embedded into plastic and the composite strand thus obtained is chopped into granular composite. The loose packing of the fibers in this granulate leads to a more easy dispersion of the fibers through the plastic during the hot plasticising and compounding of a mixture of plain resin granules with the aforementioned composite granules. The injection molding process conditions can then be chosen within considerably wider limits and still lead to a good dispersion.

In addition to achieving an effective fiber dispersion, it is also necessary to maintain maximum shielding efficiency over the widest possible frequency range under a variety of molding conditions (e.g. higher injection molding pressure or higher speed of injection) while maintaining the lowest possible volume % of fibers in the molded plastic article. This means that the aim is to come as close as possible to a substantially continuously conductive network of fibers in the plastic at the lowest possible fiber content. High L and L/D-values certainly contribute in this respect, especially at lower frequencies. These values will also be fostered by an increased fiber tensile strength, an increased bending strength and increased resistance to torque. It is, however, equally important that the fibers should also have the greatest possible effective length "1". This effective length 1 will normally approach L, to the extent that the fibers have been embedded more or less straightened into the plastic. In practice this implies the use of fibers with a relatively high bending stiffness. This stiffness can be increased by choosing a larger fiber diameter but this choice is limited by the necessity to maintain appropriate L/D-values which will normally be between 100 and 2000. An increase in the intrinsic bending stiffness (modulus) of the fiber material will therefore generally have a favourable effect.

It is therefore an object of the present invention to provide a composite strand for incorporation into resins, said strand comprising metal fibers embedded as bundles in a polymer, in which the metal has been derived from an austenitic ferric alloy, in which alloy the austenite present has been converted into martensite for at least 85 volume percent and in which at least one of said bundles consists of gear crimped fibers, and the resin content in the strand is between 20 and 80 volume percent. and whereby a very good electromagnetic shielding efficiency (e.g. ≥ 35 dB E-field shielding at fiber concentrations below 1 %) can be realized at high as well as at low Frequencies (50 Hz to 10 GHz. under widely different processing conditions. As described above, this implies amongst other things the maintenance of high L, L/D and 1-values of the dispersed fibers.

According to the present invention this object is achieved by using metal fibers comprising a hardened material (which is preferably hardened by plastic deformation), derived from an austenitic ferric alloy in which at least 85 % of the austenite has been converted into martensite.

In general, the invention thus provides for the use of conductive fibers to be incorporated into nonconductive or poorly conductive materials, whereby the fibers contain hardened material derived from

an austenitic ferric alloy in which at least 85 % of the austenite has been converted into martensite.

More in particular, the hardened material will be a stainless steel alloy, viz. an austenitic Fe/Cr/Ni-steel (18-8 types as for instance the series 302, 347, 308 and 316) in which the conversion into at least 75 % martensite has been realized by (cold), plastic deformation. It has been found that in order to achieve a sufficiently high shielding efficiency according to the invention under a wide range of processing conditions and over a broad frequency range at least 85 % and preferably often even more than 90 % martensite is desirable. It is to be noted that an increased martensite content will also increase the breaking strength and thus favour the L and L/D-values. Similarly, a higher martensite content may also increase the stiffness to a certain extent and thus also the 1-values.

In order to guarantee an almost constant bending stiffness in the fibers, the cross section of these fibers will preferably remain almost constant over their entire length and also be as round (circular) as possible. The cross section can for instance be an almost regular polygon, for instance a hexagon. A constant and near-circular cross section also favourably affects the achievement of a regular and almost smooth fiber surface, which is a desirable characteristic.

The L and L/D-values can also be increased by using relatively pure metals, i.e. metals or alloys that are almost free from non deformable inclusions with a grain size of 3 µm or more. Indeed fiber breakage is often observed to occur close to such inclusions.

It has also been found to be important to use fibers having a surface with a good conductivity. which is for instance little or poorly oxidized. Indeed the contact or transition resistance between adjacent fibers increases considerably when their surfaces have or acquire a low conductivity. (This happens for instance with Al-fibers which acquire a strongly isolating Al_2O_3-sheath by oxidation.)

An increase in fiber diameter will in general also cause a desirable increase in stiffness. Nevertheless, the equivalent fiber diameter D will preferably be chosen below 15 µm in order not to disturb the homogeneity of the plastic matrix and thus its mechanical and physical properties. Preferred diameters are in the 4 to 12 µm range.

The strand according to the invention contains between 500 and 35000 fibers asbundles. The shear forces acting during the hot processing cause the gradual release of the fibers from the bundle. First at the outside of the bundle and then gradually towards its center. Subsequently the released fibers are distributed and dispersed through the plastic matrix. The detached fibers will, however, show a tendency to break up (possibly into fine dust) when the shear forces are maintained for too long a period of time or are too severe or too strong. Although this leads to an improved appearance of the shaped article (absence of fiber clusters) it also causes an undesirable reduction of shielding efficiency.

A very thin bundle will be released more quickly and thus be more susceptible to fiber breakage. If, on the other hand, very thick bundles are used, the outer fibers of the bundle may be released and thus become dispersed and susceptible to fiber breakage before the bundle core fibers have been released. This also leads to uncontrolled changes in L and L/D-values during processing and affects the shielding efficiency. Easy release and dispersion of the bundle will also depend upon the cross section shape of the bundle. A circular bundle will in general be released more slowly than a flat, striplike bundle with a smaller thickness than width. In addition to the bundle thickness, other significant factors are fiber strength, fiber length in the granulate chopped from the strand and the degree of compactness of the packing of the fibers therein, as well as the amount (volume %) in the resin and its melt viscosity.

The desirable fiber hardening and fiber strength have already been dealt with. The length of the chopped granulate will preferably be between 2.5 and 10 mm, which is thus also substantially the length of the fibers embedded. therein and extending rom one end of the granule to the opposite end.

If the granular composite according to the invention contains a thermoplastic resin, it can be dry mixed with (an)other thermoplastic resin (e.g. pellets) in a ratio according to a predetermined content of conductive fibers. This mixture can then be fed to plastification equipment and after hot working it can be shaped in the usual manner into a plastic article (master batch). The conductive fibers are then distributed as evenly as possible throughout the entire article or only through predetermined parts thereof. The length of the composite granules is then preferably between 2.5 and 6 mm.

Shaping can be done by injection molding, extrusion. pultrusion. compression molding etc.

If desired it is also possible to extrude the hot mass into a new strand containing the fibers distributed in it. This compounded strand can again be chopped to form compounded granulate to be dry mixed with other resin granulate. This mixture can then be hot worked and fed to shaping equipment or a mold as described above, for the manufacture of more or less conductive plastic articles. If the pre-compounding route (with compounded granulate) is chosen, the length of the initial composite granulate is preferably between 4 and 8 mm.

The use of at least one gear crimped fiber subbundle in the strand allows the compactness of the fiber

arrangement in the strand and the (composite) granulate to be controlled. According to the teaching of the abovementioned Belgian patent application 8700067 (EP-A-0 278 546) the crimp can be an almost sinusoidal zigzag crimp with a wave length W between 2 and 30 mm (and preferably between 4 and 20 mm) and an amplitude A between 0.2 and 7 mm, whereby W/A > 2 and preferably ≥ 4. The crimp wave can also consist of a number of superimposed zigzag crimps. The voluminosity of the bundle can also be influenced for example by combining a number of bundles with different crimp characteristics in the same strand. Further, metal fibers can be combined in the same strand with other fibers, either non-conductive fibers (e.g. glass fibers) or fibers with a conductivity of less than 0.5 % of the copper standard (e.g. carbon fibers). Multifilament bundles or staple fiber slivers can be used alone or in combination.

The resin content in the strand must be between 20 and 80 volume percent. Resin volumes below 20 % entail the risk of producing a fragile strand with too little cohesion, whereas resin volumes above 80 % would have little effect and may even retard the gradual release and dispersion of the fibers. Naturally, the resin in the strand must be chemically substantially compatible with the main resin component of the article to be shaped.

In order to encourage a rapid dispersion, the strand polymer preferably has a relatively low melt viscosity, preferably lower than the melt viscosity of the main resin component of the article to be shaped. The strand polymer preferably also has good filmforming properties. In certain cases it can also have the same or almost the same composition as the main resin component, for instance when thin bundles (± 1000 filaments) are used. Plasticisers and/or lubricants can also be added to improve the fluidity properties during processing.

If so desired, very finely divided highly polar organic compounds or electrically conductive materials can be added to the strand. These encourage the formation of electrically conducting bridges between adjacent dispersed fibers in the article. These compounds or materials may thus compensate the presence of poorly conductive metal oxides on the fiber surfaces. Similarly, the addition to the polymer of the strand of certain coupling bonding or wetting agents, such as silanes, titanates and zirconates can be considered in order to control the adhesion of the fiber surfaces to the polymer matrix into which these fibers are to be dispersed. These additives may exert a favourable influence on the ageing properties of the plastic articles. (In this context ageing includes the decrease of the shielding efficiency with time and/or changes in temperature.

The abovementioned finely divided conductive or polar compounds (possibly in combination with antioxidants, coupling agents or wetting agents) can also be chosen so as to achieve an improved corrosion resistance and better fluidity. properties in addition to improved electrical conductivity and adhesion. If so desired, attempts can be made to chemically convert poorly conductive oxides on the fiber surfaces by the coupling agents to encourage the formation of a conductive bridge from the fiber to the polymer matrix.

Finally, the resin impregnated bundles as described above may be extrusion coated with a further polymer layer, which layer may have the same or almost the same composition as the polymer used for the impregnation of the fiber bundles. This additional polymer may in certain cases also have the same or almost the same composition as the main polymer constituent of the plastic article, if for instance polycarbonate resin is used. Similarly, the composition of the impregnating resin of the fiber bundles may correspond to the main polymer of the plastic article and said fiber bundle may be optionally coated with a layer of the same polymer.

Example 1

A number of different resin compositions were prepared by mixing resin granulate with granular composite according to the invention for the injection molding of plastic articles with electromagnetic shielding properties over a wide frequency range.

The granular composite mentioned above was prepared substantially as in example 1 of the aforementioned U.K. patent. Each granule contained gear crimped stainless steel filaments embedded in a linear polyester (Dynapol L850) and a sheath of a modified alkyd resin with good fluidity properties. The crimp in the gear crimped filaments was attained by superimposition of two zigzag waves with wave lengths of 7.5 and 5 mm and amplitudes of 1 and 0.7 mm respectively. The cylindrical composite strand had a diameter of about 2 mm and a metal fiber content of about 30 vol. %. It was chopped into 4 mm long composite granules. Subsequently, this granulate was dry mixed with the usual ABS-resin based granules (RONFALIN VE-30®) to give a master batch mixture containing 1 vol. % metal fibers. The mixture was fed to a Stubbe injection molding machine as described in example 6 of the aforementioned U.K. patent. The extrusion nozzle temperature was controlled at 220 - 240 °C and the screw speed was 70 rpm and 100 rpm respectively. The injection molded square plaques (150 x 150 mm) had a thickness of 3 mm. Four Fe/Cr/Ni-

stainless fiber types with different martensite contents (%) were used : Table 1.

Table 1

Sample No.	Steel type	Mart. %	Composite granulate	
			D (µm)	No. fibers
1 *	316 L	77	10	8 000
2 *	316 L	76	10	8 000
3	316 L	92	8	12 000
4	302	93	8	12 000
5 *	316 L	78	10	8 000
6	302	87	8	12 000
7	302	86	10	8 000
8	316 L	85	8	10 000
9	316 L	89	8	10 000

* Comparative Examples

The 316 L-alloys had a high degree of purity : they contained few non-deformable inclusions. Amongst the Fe/Cr/Ni-alloys those with a relatively low Ni-content (≤ 10.5 %) will generally be preferred. because they form more readily martensite during the plastic deformation process during fiber manufacture. The plastic deformation and hardening are preferably introduced during manufacture by a process of bundle drawing as described e.g. in U.S. patents 2.050.298 or 3.277.564. It is known that high martensite rates can then be obtained by an appropriate choice of the drawing parameters such as temperature, number of drawing stages reduction per drawing stage and final reduction as well as in function of the alloy composition.

The martensite contents were determined in the usual manner, by measuring the ferromagnetic character, i.e. the volume percentage of ferromagnetic material in the fiber, using a sigmameter B3513. For this purpose, the fibers were magnetized to saturation and suddenly removed from the magnetic field, thus causing an inductioncurrent to be generated in nearby coils, which current is recorded by a ballistic galvanometer. From this record the proportion ferro-magnetic material in the fiber mass can be deduced.

The reflection values (observed during microwave measurements at 10 GHz in the far field) have been recorded in Table 2 for several plasticising pressures and screw speeds.

Table 2

Plasticising pressure N/cm^2	Screw speed rpm	R (%) per sample number								
		1	2	3	4	5	6	7	8	9
2.0	70	-	-	90	-	87	-	-	-	-
2.5	70	88	87	-	91	-	90	88	88	90
3.0	70	-	-	-	-	86	-	-	-	-
3.5	70	86	87	90	90	-	90	88	89	90
4.0	70	-	-	-	-	83	-	-	-	-
4.5	70	-	-	-	91	-	91	87	82	89
4.5	100	-	86	90	-	-	-	-	-	-
5.0	70	-	-	-	-	74	-	-	-	-
5.5	70	-	-	-	-	-	-	-	80	88
5.5	100	82	-	-	93	-	90	87	77	86

Table 2 reveals that sample numbers 3, 4, 6 and 9 with 8 µm fibers and with martensite contents from 87 % onwards show on average the highest reflection values. It should also be noted that the reflection values of the high martensite content samples are the best for high as well as low plasticising pressures. Further they decrease on average less rapidly with increasing shear forces than for low martensite content samples.

The introduction and dispersion into non- or poorly conductive substances of hardened metal fibers according to the invention need not necessarily be achieved by the addition of composite granulate as described above. It can also be introduced by means of a woven, knitted or non-woven structure. A mixture of metal fibers and other fibers can thereby be used. The other fibers can comprise then low melting polymers.

On introduction into plastics and subsequent hot shaping, the low melting polymer will then fuse and flow with the (compatible) main resin of the intended conductive composite article.

Although the invention recommends metal fibers derived from austenitic ferric alloys with high martensite content. a favourable shielding effect from the use of hardened ferritic Fe/Cr-alloys (e.g. from the 430 series), or of martensitic Fe/Cr-alloys (e.g. from the 410 or 416 series), or of other hardened ferromagnetic alloys may not be excluded.

Claims

1. A composite strand for incorporation into resins, said strand comprising metal fibers embedded as bundles in a polymer, in which the metal has been derived from an austenitic ferric alloy, in which alloy the austenite present has been converted into martensite for at least 85 volume percent and in which at least one of said bundles consists of gear crimped fibers, and the resin content in the strand is between 20 and 80 volume percent.

2. A strand according to claim 1, in which the metal has been hardened by plastic deformation.

3. A strand according to claim 1, in which the metal is an austenitic stainless Fe/Cr/Ni-steel, in which steel martensite has been formed by plastic deformation.

4. A strand according to claim 1, in which at least 90 % of the austenite has been converted into martensite.

5. A strand according to claim 1, in which the fibers have an almost constant and near-circular cross section.

6. A strand according to claim 1, in which the metal is almost free from non deformable inclusions with a grain size of more than 3 µm.

7. A strand according to claim 1, in which the fibers have an equivalent diameter D of not more than 15 µm.

8. A strand according to claim 1, in which the bundle assembly contains between 500 and 35 000 fibers.

9. A strand according to claim 1, in which in addition to metal fibers other fibers are present.

10. A strand according to claim 9, in which at least part of the other fibers are non-conductive.

11. A strand according to claim 9, in which at least part of the other fibers are conductive and have a conductivity lower than 0.5 % of the copper standard.

12. A strand according to claim 1, in which the polymer has a relatively low melt viscosity.

13. A strand according to claim 1, in which the polymer is the same or almost the same as the main resin component.

14. A strand according to claim 1, in which the polymer contains very finely divided, electrically conductive materials.

15. A strand according to claim 1, in which the polymer contains coupling agents to control the adhesion of the fiber surfaces to the polymers.

16. A strand according to claim 1, in which said strand contains a number of fiber bundles impregnated

with resin, the bundled arrangement being surrounded by an additional polymer layer.

17. A strand according to claim 16, in which the additional polymer layer has the same or almost the same composition as the polymer used for impregnating the bundles.

18. A strand according to claim 16, in which the additional polymer layer has the same or almost the same composition as the main resin component of the plastic article.

19. A strand according to claim 1, in which the width of said strand is larger than its thickness.

20. A granular composite obtained by chopping granules from a strand according to any of the previous claims, in which the fibers predominantly extend from one end of the granule to the opposite end.

21. A molding compound used for shaping plastic articles, comprising a mixture of granular composite according to claim 20 with another resin.

22. A plastic article obtained by shaping the compound according to claim 21, in which the conductive fibers are evenly distributed in predetermined parts of the article or throughout the entire article.

23. The use of conductive fibers for incorporation into non-conductive materials, said conductive fibers comprising hardened material which is derived from an austenitic ferric alloy, the austenite in said alloy having been converted for at least 85 % into martensite.

Patentansprüche

1. Verbundstoff-Strang zum Einbau in Harze, wobei der Strang Metallfasern umfaßt, die als Bündel in ein Polymer eingebettet sind, bei welchem das Metall von einer austenitischen eisenhaltigen Legierung abgeleitet worden ist, in welcher Legierung der vorhandene Austenit zu mindestens 85 Vol.-% in Martensit umgewandelt worden ist und in welchem wenigstens eines der Bündel aus, bspw. mittels Zahnrädern, gekrippten bzw. gekräuselten (gear crimped) Fasern besteht und der Harzgehalt in dem Strang zwischen 20 und 80 Vol.-% beträgt.

2. Strang nach Anspruch 1, bei welchem das Metall durch plastische Deformation gehärtet wurde.

3. Strang nach Anspruch 1, bei welchem das Metall ein austenitischer rostfreier Fe/Cr/Ni-Stahl ist, in welchem Stahl Martensit durch plastische Deformation gebildet wurde.

4. Strang nach Anspruch 1, bei welchem wenigsten 90% des Austenits in Martensit umgewandelt wurden.

5. Strang nach Anspruch 1, bei welchem die Fasern einen annähernd konstanten und nahezu kreisförmigen Querschnitt aufweisen.

6. Strang nach Anspruch 1, bei welchem das Metall nahezu frei von nicht verformbaren Einschlüssen mit Korngrößen von mehr als 3µm ist.

7. Strang nach Anspruch 1, bei welchem die Fasern einen äquivalenten Durchmesser von nicht mehr als 15µm aufweisen.

8. Strang nach Anspruch 1, bei welchem die Bündelanordnung zwischen 500 und 35000 Fasern enthält.

9. Strang nach Anspruch 1, bei welchem zusätzlich zu Metallfasern andere Fasern vorhanden sind.

10. Strang nach Anspruch 9, bei welchem wenigstens ein Teil der anderen Fasern nicht leitfähig ist.

11. Strang nach Anspruch 9, bei welchem wenigstens ein Teil der anderen Fasern leitfähig ist und eine Leitfähigkeit von weniger als 0,5% des Kupferstandards aufweisen.

12. Strang nach Anspruch 1, in welchem das Polymer eine relativ niedrige Schmelzviskosität aufweist.

13. Strang nach Anspruch 1, bei welchem das Polymer das gleiche oder nahezu das gleiche wie die Haupt-Harzkomponente ist.

14. Strang nach Anspruch 1, bei welchem das Polymer sehr fein zerteilte, elektrisch leitfähige Materialien enthält.

15. Strang nach Anspruch 1, bei welchem das Polymer Kopplungsmittel enthält zur Steuerung der Adhäsion der Faseroberflächen zu den Polymeren.

16. Strang nach Anspruch 1, bei welchem der Strang eine Anzahl von Faserbündeln enthält, die mit Harz getränkt sind, wobei die gebündelte Anordnung von einer zusätzlichen Polymerschicht umgeben ist.

17. Strang nach Anspruch 16, bei welchem die zusätzliche Polymerschicht die gleiche oder annähernd die gleiche Zusammensetzung aufweist wie das zum Tränken der Bündel verwendete Polymer.

18. Strang nach Anspruch 16, bei welchem die zusätzliche Polymerschicht die gleiche oder annähernd die gleiche Zusammensetzung aufweist wie der Haupt-Harzkomponente des Kunststoff-Gegenstands.

19. Strang nach Anspruch 1, bei welchem die Breite des Strangs größer ist als seine Dicke.

20. Körniger Verbundstoff, erhalten durch Abhacken von Körnern von einem Strang nach einem der vorhergehenden Ansprüche, bei welchem die Fasern sich überwiegend von einem Ende des Korns zum gegenüberliegenden Ende erstrecken.

21. Preßmasse, verwendet zum Formen von Kunststoff-Gegenständen, umfassend eine Mischung von körnigen Verbundstoffen nach Anspruch 20 mit einem weiteren Harz.

22. Kunststoffgegenstand, erhalten durch Formen der Masse nach Anspruch 21, bei welchem die leitfähigen Fasern gleichmäßig in vorbestimmten Teilen des Gegenstands oder in dem gesamten Gegenstand gleichmäßig verteilt sind.

23. Verwendung leitfähiger Fasern zum Einbau in nicht leitfähige Materialien, wobei die leitfähigen Fasern gehärtetes Material umfassen, das von einer austenitischen eisenhaltige Legierung abgeleitet ist, wobei der Austenit in der Legierung zumindest zu 85% in Martensit umgewandelt wurde.

Revendications

1. Toron composite pour incorporation dans des résines, ledit toron comprenant des fibres métalliques incorporées en faisceaux dans un polymère, dans lesquelles le métal provient d'un alliage de fer austénitique, alliage dans lequel au moins 85 % en volume de l'austénite présente ont été transformés en martensite et au moins l'un desdits faisceaux consiste en fibres frisées par engrenage, la teneur en résine du toron valant de 20 à 80 % en volume.

2. Toron selon la revendication 1, dans lequel le métal a été durci par déformation plastique.

3. Toron selon la revendication 1, dans lequel le métal est un acier Fe/Cr/Ni inoxydable austénitique, dans lequel de la martensite d'acier a été formée par déformation plastique.

4. Toron selon la revendication 1, dans lequel au moins 90 % de l'austénite ont été transformés en martensite.

5. Toron selon la revendication 1, dans lequel les fibres présentent une section droite constante et quasi-circulaire.

6. Toron selon la revendication 1, dans lequel le métal est pratiquement exempt d'inclusions non déformables dont la dimension de grains est supérieure à 3 μm.

7. Toron selon la revendication 1, dans lequel les fibres ont un diamètre équivalent D ne dépassant pas

15 µm.

8. Toron selon la revendication 1, dans lequel l'assemblage du faisceau contient entre 500 et 35000 fibres.

9. Toron selon la revendication 1, dans lequel, en plus des fibres métalliques, d'autres fibres sont présentes.

10. Toron selon la revendication 9, dans lequel au moins une partie des autres fibres n'est pas conductrice.

11. Toron selon la revendication 9, dans lequel au moins une partie des autres fibres est conductrice et possède une conductivité inférieure à 0,5 % par rapport au cuivre.

12. Toron selon la revendication 1, dans lequel le polymère présente une viscosité à l'état fondu relativement basse.

13. Toron selon la revendication 1, dans lequel le polymère est le même ou presque le même que le composant résine principal.

14. Toron selon la revendication 1, dans lequel le polymère contient des matériaux électroconducteurs très finement divisés.

15. Toron selon la revendication 1, dans lequel le polymère contient des agents d'accrochage pour réguler l'adhérence des surfaces de fibres aux polymères.

16. Toron selon la revendication 1, dans lequel ledit toron contient un certain nombre de faisceaux de fibres imprégnées de résine, une couche de polymère supplémentaire entourant l'ensemble des faisceaux.

17. Toron selon la revendication 16, dans lequel la couche de polymère supplémentaire possède la même ou presque la même composition que le polymère utilisé pour imprégner les faisceaux.

18. Toron selon la revendication 16, dans lequel la couche de polymère supplémentaire possède la même ou presque la même composition que le composant résine principale de l'article en matière plastique.

19. Toron selon la revendication 1, dans lequel la largeur dudit toron est plus grande que son épaisseur.

20. Composite granulaire obtenu par hachage de granules à partir d'un toron selon l'une quelconque des revendications précédentes, dans lequel les fibres s'étendent surtout d'une extrémité des granules jusqu'à l'extrémité opposée.

21. Composition de moulage utilisée pour mettre en forme des articles en matière plastique, comprenant un mélange de composite granulaire selon la revendication 20 avec une autre résine.

22. Article en matière plastique obtenu par mise en forme de la composition selon la revendication 21, dans lequel les fibres conductrices sont réparties uniformément dans des parties prédéterminées de l'article ou dans l'article tout entier.

23. Utilisation de fibres conductrices pour leur incorporation dans des matériaux non conducteurs, lesdites fibres conductrices comprenant un matériau durci provenant d'un alliage de fer austénitique, l'austénite dudit alliage ayant été transformée en martensite à raison de 85 % au moins.